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ARTIFICIAL DRYING OF RICE ON THE FARM

By W. D. Smith, *senior marketing specialist*, J. J. Deffes, and C. H. Bennett, *junior supervisors in grain inspection, Grain Division, Bureau of Agricultural Economics*, and W. M. Hurst, *associate agricultural engineer*, and W. H. Redit, *junior agricultural engineer, Division of Mechanical Equipment, Bureau of Agricultural Engineering.*[1]

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INTRODUCTION

Observations made on a farm in the South a few years ago indicated that the combined harvester-thresher might be used to advantage in reducing the cost of harvesting rice, but that it would be necessary to dry the rice artificially if the combine were used. Since that time several farmers have used the combine to harvest their rice crop and have dried the threshed rice with commercial driers. But observations and tests made on farms in Arkansas and in Texas where combines and artificial driers were used in 1929, 1930, and 1931 show that the regular grain combine is not entirely suitable for harvesting rice in those areas, both because of the presence of wet fields and irrigation levees, and of the green or immature condition of the rice straw at harvest time. Attempts are being made by some farm-machinery manufacturers to develop a combine that will be suitable to rice-field conditions.

The investigations here reported show that the method of combine harvesting and artificial drying, if properly carried out, eliminates damage to the rice from unfavorable weather, reduces loss from shattering, and produces rice of higher milling quality and a more uniform product than does the common method of harvesting with a binder. Tests made with both experimental and commercial grain driers show that in order to obtain rice of a high milling quality a much lower drying-air temperature must be used than is customary in drying other cereals. If a drying-air temperature as high as

[1] Acknowledgment is made to John McWilliams, Jr., and William Lawlor, Jr., who made available facilities for conducting these investigations.

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120° F. is used, the moisture content of rice should not be reduced more than about 2 percent at any one drying operation, unless that content is considerably in excess of 20 percent. If sufficient bin space is not available for storing the rice between drying operations, or if for other reasons it is necessary to dry the rice in one operation, the drying-air temperature should not exceed 110° for best results.

If rice is cut at the proper stage of maturity with the binder, is properly shocked, and no unfavorable weather occurs at harvest time, the binder method can usually be depended upon to produce rough rice of good quality. But in the rice-producing areas of the South there is a loss in the field through shattering in the handling of the bundles from the time they are dropped from the binder until they are placed in the threshing machine, and it is difficult to obtain rough rice of high quality and of good condition if the weather is unfavorable during the harvest, or during the time the grain is in the shocks.

Ordinarily, when rice is harvested with binders, the kernels have a 20 to 30 percent moisture content at time of harvesting; if allowed to stand in the field before harvesting until the moisture content is much lower than 20 percent, the kernels frequently become so checked or cracked that many of them break in milling. As the moisture content of rough rice should not exceed about 14 percent for safe storage and for high milling quality, binder-cut rice must remain in shocks to dry before being threshed. If rains are frequent or if the atmospheric humidity is high during this time, it is often almost impossible to obtain dry rough rice. Damp rice is difficult to thresh out of the heads, and in such cases some rice is usually lost with the straw.

MILLING QUALITY AND MARKET VALUE

The market value of a given lot of rough rice is determined largely by the percentage of whole-grain milled rice that can be obtained from it. Rough rice may be dry and comparatively free of the visible defects that affect its market value and yet be of relatively low milling quality because a high percentage of broken milled rice is likely to result from these defects. The hardness of rough rice (its resistance to breakage in milling) is generally referred to as "milling quality", therefore it is frequently said that milling quality chiefly determines the market value of rough rice.

Table 1 shows how the market value of rough rice would be increased with each pound of increase in yield of head rice when the milled rice [2] is valued at 2½ cents per pound for head rice and 1 cent per pound for broken rice [3]. If the yield of total milled rice remains the same in all cases, an increase of 1 pound in the quantity of head rice results in an increase in price of 1½ cents per barrel of rough rice. On this basis the milled rice obtained from a barrel of rough rice yielding 80 pounds of head rice and 110 pounds total milled rice has a value of $2.30, whereas the milled rice obtained from a barrel of rough rice yielding 90 pounds of head rice and 110 pounds

[2] Rough rice is rice from which the hulls have not been removed; head rice is milled rice consisting principally of whole kernels; and milled rice is rice from which the hulls, germs, and practically all of the bran layers have been removed.

[3] All estimates for yield of head rice in table 1 are based on tests made with the Smith shelling device.

total milled rice has a value of $2.45. The difference is 15 cents per barrel of rough rice. (A barrel of rough rice is 162 pounds.)

TABLE 1.—*Value of milled rice obtained from one barrel of rough rice when total yield remains the same (110 pounds) and head rice yield is increased, calculated on price basis of 2½ cents per pound for head rice and 1 cent per pound for broken rice.*

Yield of head rice per barrel	Yield of broken rice per barrel	Value of head rice at 2½ cents per pound	Value of broken rice at 1 cent per pound	Value of milled rice obtained from one barrel of rough rice
Pounds	*Pounds*	*Dollars*	*Dollar*	*Dollars*
75	35	1.87½	0.35	2.22½
76	34	1.90	.34	2.24
77	33	1.92½	.33	2.25½
78	32	1.95	.32	2.27
79	31	1.97½	.31	2.28½
80	30	2.00	.30	2.30
81	29	2.02½	.29	2.31½
82	28	2.05	.28	2.33
83	27	2.07½	.27	2.34½
84	26	2.10	.26	2.36
85	25	2.12½	.25	2.37½
86	24	2.15	.24	2.39
87	23	2.17½	.23	2.40½
88	22	2.20	.22	2.42
89	21	2.22½	.21	2.43½
90	20	2.25	.20	2.45
91	19	2.27½	.19	2.46½
92	18	2.30	.18	2.48
93	17	2.32½	.17	2.49½
94	16	2.35	.16	2.51
95	15	2.37½	.15	2.52½
96	14	2.40	.14	2.54
97	13	2.42½	.13	2.55½
98	12	2.45	.12	2.57
99	11	2.47½	.11	2.58½
100	10	2.50	.10	2.60

The effect of the loss of moisture on the hardness of rough rice is indicated by results obtained in experiments in which wet rough rice was allowed to dry naturally. Samples of wet lots of rough rice were placed in open pans in a laboratory. The samples were tested daily for moisture and for milling quality. Figure 1 shows that as the rice became drier there was in each case a corresponding improvement in the milling quality of the rice.

When damp or wet rice is milled a large number of the kernels break, thus reducing the yield of head rice per barrel of rough rice. The yield of head rice usually increases with a decrease in moisture until the moisture content has been reduced to between 12 and 14 percent.

Other things being equal, dry rough rice is of higher milling quality than is rice with a high moisture content, and it is very important, from the standpoint of market value, that the moisture content of all rough rice be reduced to the point at which the rice attains its maximum milling quality. Since there is a very considerable difference in value between similar lots of dry rough rice of high and of low milling quality, it is very important that the artificial drying of the rice be performed by a method that will harden the rice and render it resistant to breakage in milling.

Each season the moisture content of rough rice has a material effect upon the marketing of the milled rice produced from the crop.

When the crop is damp or wet a large part of the rice heats or becomes stack-burned while in storage, and the resulting milled rice is of poor appearance. Such milled rice is difficult to sell. Milled rice containing excess moisture sometimes heats and becomes spoiled while in transit; this causes disputes between buyers and sellers. As foreign buyers object to milled rice that contains more than 14.5 percent moisture, exports of milled rice almost invariably decline during wet seasons owing to excess moisture in the milled product.

The moisture content of rough rice produced in the Southern States during the 5 years 1922 to 1927 inclusive, is shown in figure 2. According to the 3,300 samples tested, the average moisture content for each crop of rice, by years, ranged from 12.6 to 14.8 percent. The proportion of the crops that contained excess moisture (more than 14 percent) varied from year to year. According to the samples tested only 18.6 percent of the 1924 crop contained excess moisture, though the percentage for the 1925 crop was slightly more

FIGURE 1.—Increase in estimated yield of head rice with loss of moisture in rough rice when dried under normal atmospheric conditions.

than 69. Only about 51 percent of the samples contained 14 percent or less of moisture. About 29 percent of the samples contained more than 14 but not more than 15.5 percent of moisture, and were classed as damp; about 15 percent of the samples contained more than 15.5 but not more than 17 percent of moisture, and were classed as wet; and about 4.5 percent of the samples contained more than 17 percent of moisture and were classed as Sample grade.

METHODS OF HARVESTING IN RELATION TO ARTIFICIAL DRYING

During seasons when prices are low it is particularly important to the grower that he obtain as high a price as possible. The cost of producing low-quality and high-quality rice is roughly the same. There are certain fixed charges that do not vary a great deal with the quality of rice produced. The profit or loss on the farming operations for the year may be determined to a large extent in the harvesting. The milling quality of the rough rice and its market value are governed largely by weather conditions and the method of harvesting. Some of the newer harvesting methods that have been tried in the Southern States, in an effort to reduce harvesting costs and to obtain high-quality rice during wet seasons, have employed the combine-harvester, windrower, and the header.

WINDROW HARVESTING

The windrow method of harvesting in the South is handicapped by weather hazards. Heavy rains frequently flood the rice fields during the harvest season to a depth of several inches. Even under ordinary conditions the milling quality of rough rice may be impaired by the repeated wetting and drying which result from dews, rains, and sunlight. The milling quality of windrowed rice may suffer considerably if the moisture content is reduced too rapidly. Likewise, if the heads hang downward or if they are exposed on top

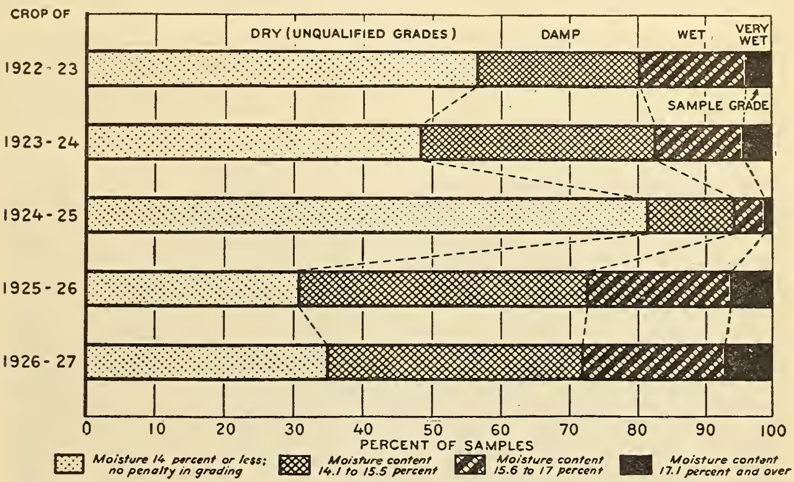

Figure 2.—Moisture content of rough rice produced in the Southern States, 1922–27, showing the variation in the percentage of samples of rough rice that contained 14 percent or less of moisture, and that graded as Damp, Wet, and Sample grade, on the moisture factor, during the years 1922–27.

of the swath the rice kernels are likely to be damaged badly in wet weather.

To determine whether a windrower equipped with an elevator for loading the headed rice into a wagon pulled beside the windrower could be used advantageously when a drier was available, such equipment was tried in Arkansas during the 1930 harvest season. The light windrower can be operated in wet fields, but some difficulty was experienced in keeping the wagon under the elevator when crossing levees. Difficulty also was experienced in threshing the headed rice with a stationary thresher. Therefore attempts to use the machine were not made on other farms.

USE OF COMBINED HARVESTER-THRESHER

The combined harvester-thresher, generally known as the combine, cuts and threshes at one operation. It was developed primarily for harvesting wheat, but it has been used with considerable success for harvesting a variety of similar crops.

In the fall of 1929, observations and tests were made on one farm in Texas and another farm in Arkansas, on which rice was harvested with a combine and dried with a commercial drier. Further observations and tests were made on the same farms during the harvest seasons of 1930 and 1931. Field observations and studies dealing with some of the mechanical and economic factors involved in artificial drying were also made.

On the farms under observation it has not been possible to harvest as many acres per day with a combine as with a binder with the same width of cut. Apparently a rice grower may have to operate as many combines in a field as he has been operating binders in order to cut all the rice at the proper stage of maturity, at least unless mechanical improvements are made in the combine that will render this machine better suited to rice-field conditions. To attempt to harvest a large acreage of rice with only one combine

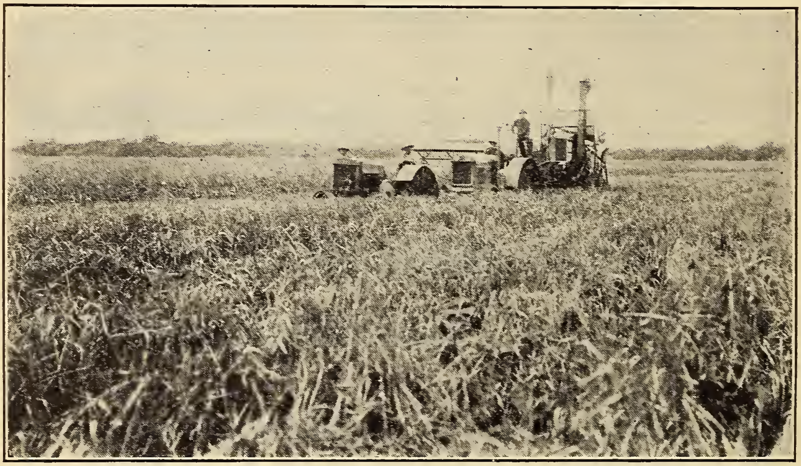

FIGURE 3.—A 12-foot combine pulled by two tractors.

would probably mean that some of the rice would become overripe and be of poor milling quality before being cut.

Low wet spots and weed patches, and high narrow levees that run through the fields make it difficult to harvest rice with a combine. Rice growers who have operated combines realize that their levees must be made low and broad. Figure 3 shows a 12-foot combine in operation in a rice field in which it was necessary to use two tractors.

In the South the rice stalk, or stem, is usually green at harvest time; the warm humid weather that frequently prevails during the harvest season and the water-soaked soil often combine to keep the plants alive after the rice is ready to harvest. The combine can cut and thresh rice under such conditions but the green straw has a tendency to clog the machine, often necessitating frequent stops.

There are numerous advantages, however, in harvesting rice with a combine and drying it artificially. In one operation the rice is removed from the fields with no danger of weather damage; there is very little loss of rice through shattering; rice of high milling quality can be obtained regardless of weather conditions at harvest; and all of the rice can be thoroughly and uniformly dried, making it safe for storage either in bulk or in sacks. Combine-harvested rice that has been artificially dried is usually more uniform in quality than rice handled in the customary way; this is because of the thorough mixing of the lot during the drying operations.

EXPERIMENTS IN ARTIFICIAL DRYING

When rough rice is properly dried artificially usually the hardness of the kernels increases as the moisture content of the rice decreases. As the principal objective is to lower the moisture content so as to increase the hardness of the rice, the temperature of the drying air must be high enough to remove the moisture from the rice, but not so high that it will injure the milling quality.

In the artificial drying of rough rice observed in Arkansas, drying-air temperatures of from 94° to 113° F. were used; the temperature usually averaged between 100° and 110° with an exposure of approximately 1 hour for individual operations.

In the operations observed in Texas, a drying-air temperature of approximately 120° F. was used. It was found that, by increasing the temperature to 120° and reducing the period of exposure, the capacity of the drier could be increased materially without injuring the quality of the rice. But for the best results when a drying-air temperature as high as 120° is used, the moisture content should not be reduced more than 2 percent further at any one drying operation after it has reached 20 percent.

TABLE 2.—*Hardening effect on kernels when damp or wet rough rice of several varieties was dried artificially*

Variety	Moisture			Whole kernels in shelling test			Indicated yield of head rice per barrel after drying
	Before drying	After drying	Loss	Before drying	After drying	Increase	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Pounds*
Storm Proof	19.9	14.3	5.6	54.6	63.8	9.2	86
	18.3	14.9	3.4	53.0	66.3	13.3	89
	17.1	13.4	3.7	60.5	71.9	11.4	97
	20.7	14.9	5.8	45.9	67.9	22.0	91
Early Prolific	17.5	13.7	3.8	72.8	74.8	2.0	101
	22.2	14.5	7.7	42.5	62.3	19.8	84
	17.0	14.4	2.6	61.1	66.0	4.9	89
	22.9	14.7	8.2	36.7	65.8	29.1	89
	23.6	14.8	8.8	38.0	66.9	28.9	90
	15.3	14.7	.6	66.3	68.6	2.3	92
	23.6	14.1	9.5	37.8	67.9	30.1	91
	26.8	14.1	12.7	25.1	69.3	44.2	93
	24.5	14.0	10.5	45.0	68.2	23.2	91
	24.1	14.3	9.8	40.4	69.8	29.4	94
	24.1	13.9	10.2	39.1	68.0	28.9	91
	26.5	14.5	12.0	29.9	69.1	39.2	93
	22.6	14.5	8.1	41.6	63.8	22.2	86
	22.5	13.4	9.1	47.4	67.3	19.9	91
	21.0	13.6	7.4	54.2	67.3	13.1	91
	14.9	14.0	.9	61.1	65.6	4.5	88
	15.6	14.6	1.0	64.7	65.8	1.1	89
	16.5	14.3	2.2	66.3	68.8	2.5	93
	16.3	14.9	1.4	60.7	63.8	3.1	86
	15.6	14.5	1.1	64.3	65.2	.9	87
	15.8	14.4	1.4	58.1	63.4	5.3	85
	17.0	14.7	2.3	53.3	64.6	11.3	87
	20.1	14.8	5.3	50.3	59.0	8.7	80
	20.3	14.4	5.9	43.7	59.3	15.6	80

TABLE 2.—*Hardening effect on kernels when damp or wet rough rice of several varieties was dried artificially*—Continued

Variety	Moisture			Whole kernels in shelling test			Indicated yield of head rice per barrel after drying
	Before drying	After drying	Loss	Before drying	After drying	Increase	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Pounds*
Fortuna	18.7	14.7	4.0	23.2	56.8	33.6	78
	14.7	13.8	.9	39.0	50.7	11.7	73
	15.5	13.7	1.8	43.4	55.5	12.1	77
	15.5	14.1	1.4	38.1	46.4	8.3	69
Blue Rose	16.3	14.2	2.1	73.6	75.9	2.3	102
	24.8	13.8	11.0	38.0	75.0	37.0	101
	25.1	13.9	11.2	34.9	72.3	37.4	97
	27.4	14.6	12.8	29.7	73.8	44.1	99
	26.8	14.1	12.7	26.8	74.7	47.9	100
Japan	19.4	13.7	5.7	46.4	72.0	25.6	97

The hardening effect on the kernels when damp or wet rough rice was dried artificially is shown in table 2. In table 2 the results obtained by artificial drying of several lots of different varieties are shown. For each lot there was a very appreciable increase in hardness, resulting in an increase of whole milled-rice kernels when rough rice with a high moisture content was dried to a lower moisture content.

The milling quality of each lot, as indicated by the official shelling test, is shown in table 2. For most of these lots the indicated yield of head rice is as high or higher than is usually expected from an average lot of rough rice of the variety involved. The milling quality of some of the lots probably would have been higher had the moisture content of these lots been reduced to 14 percent. Reports obtained of the actual milling outturns from several of the lots dried under observation show that better-than-average mill yields were obtained from some of the lots.

When samples of the artificially dried rice were tested immediately after drying, and after the lapse of some time, it was indicated that such rice improves in milling quality when allowed to remain in storage for a few days after drying. This is probably because of the unequal distribution of moisture in the outer and inner parts of the kernel immediately after drying. When an even diffusion of moisture has been accomplished in the kernel it is more resistant to breakage.

Evidently rough rice that is artificially dried on a farm should not be shipped to a mill for immediate milling, and probably should not be offered for official grading or for sale immediately after being dried. A better indication of milling quality will be obtained if the rice is tested after it has been stored for a few days.

When a drier is installed at a rice mill it apparently would be desirable to have a bin between the drier and the mill and to hold the dried rough rice for a time before milling instead of milling it immediately as is usually done at present.

At one of the driers under observation there was so much rice to be dried that, to protect the quality and condition of each lot, it became the practice partly to dry each lot as soon as it was brought from the combine. The rice was then put into a bin where its partly dried condition insured that it would keep in good condition for a short time until the moisture content could be reduced by further drying. Usually, a day or two after the first drying operation, 2 or 3 of these lots were combined and given a second drying. In some instances 2 lots were put together for the second drying operation, a third being added for a third drying. By this method the moisture content of all the rice was reduced somewhat immediately after it was harvested. It then remained temporarily in good condition, elevator bin space was conserved, and time was saved through drying large lots.

So long as the rice is all of the same variety, type, and quality, it will be found more economical to handle and dry it in large lots. Care should be used to prevent mixing varieties in the drying operations. On many farms on which only one early variety and one late variety are grown there will not be great danger of mixing, as the early rice will probably be harvested and dried before the late rice is ready for harvesting. If more than one early or one late variety is grown, or if a variety is grown that matures between the early and late varieties, the drier, the elevator, the conveyor, and the bins should each be cleaned thoroughly of one variety before another is handled, because the mixing of two varieties usually results in a lowering of the market value of both.

Rice cut with a combine should usually be cleaned before it is dried. The foreign material usually has a high moisture content and is often of a kind that retards the flow of rice through the drier; its removal enables the drying air to be used solely for the rice and there is a more even flow of the grains. The cleaning machinery can also be used later for removing the lightweight rice kernels and small fragments of foreign material that may remain in the dried rice. This latter cleaning usually improves very materially the quality and market value of the rice.

COMMERCIAL RICE DRIERS

Few if any of the driers manufactured in the United States are designed specially for rice. Driers commonly used in the South for this crop are generally known as grain driers and are suitable for use in drying practically any cereal grain. Such driers may differ in details of design and construction but practically all of them are similar in that the drying air is forced through thin layers of grain—4 to 6 inches—for uniform drying. Heat may be supplied by steam coils or directly from a furnace. When steam is used, air is drawn or forced through a nest of steam coils and then is forced through the rice by a fan. With the direct-heat type of drier flue gases are drawn from a furnace, mixed with outside air in a mixing chamber, and then forced through the rice with a fan (figs. 4 and 5).

Most commercial driers are composed of two compartments, one above the other. The upper compartment is supplied with heated air for drying and the lower compartment with atmospheric air for cooling. The cooler is not so essential for rice as for some other grains, as much lower temperatures are usually used in drying rice. The temperature of the rice when discharged from the drying compartment is usually from 10° to 20° F. lower than the temperature of the drying air used, depending largely upon the temperature of the drying air and the moisture content of the rice. The evaporation of moisture from the kernels tends to keep the rice cool.

Practically all driers used for rice are so designed that the rice can be dried either in batches or by continuous flow through the drier. In batch drying the rice is held stationary in the drier compartment for the desired length of time and then dropped into the cooler, after which the drying compartment is again filled with undried rice. In the continuous-flow method, which can be used only when there is more than enough rice in a lot to fill the drier, the first charge is dried as in batch drying and then allowed to remain in the cooler for 15 or 20 minutes before the discharge mechanism is started for the continuous-flow process.

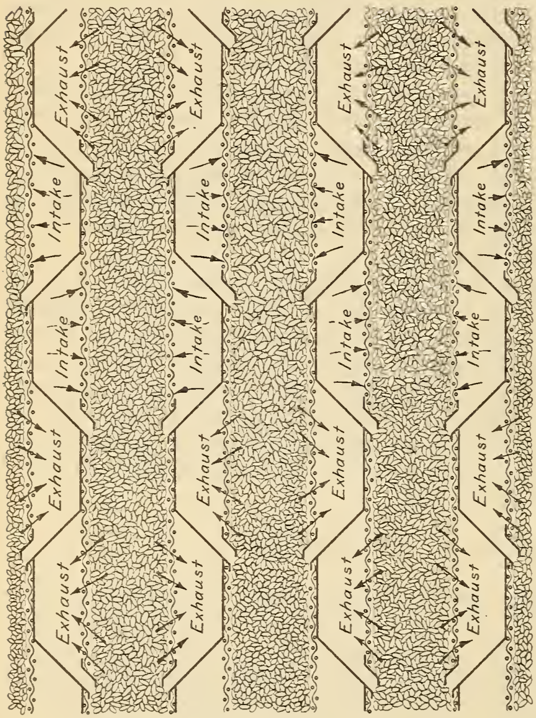

FIGURE 4.—Diagrammatic section of rice columns in drier, Nome, Tex.

INSTALLATION OF THE DRIER

Rice driers are usually located in or adjacent to an elevator, warehouse, or rice mill (figs. 6 and 7). The drier should be so located and equipped with conveying and cleaning machinery that it can be operated without interfering with other operations about the plant. When rough rice is dried artificially in a commercial drier the rice passes through the drier in bulk. It is essential for economy of operation that sufficient bin space be provided to handle the rice in bulk before drying, between drying operations, and immediately after drying. When rice is adequately dried it is safe for storage in bulk and it is economical to continue to handle it in bulk until it is milled, if sufficient storage space is available.

As damp or wet rice tends to clog in pipes and hopper-bottom bins, it is necessary to make all pipes and chutes larger and to give them more slope than is customary when dry rice is handled. Hopper bins should also be given more slope when they are to be used for damp rice.

Considerable time and labor can be saved in operation if ample provision is made for conveying the rice to and from the drier at a rapid rate. In some cases it has been found desirable to have a bin so located that the drier can be filled therefrom by gravity. This arrangement allows the operator to fill the drier quickly and reduces the time required to shift from one lot to another when the lots must be kept separate. It may also be possible for the operator to feed the drier from this bin and to shift rice from one bin to another with the elevator that is used for supplying rice to the drier.

For conveying the rice from bins to the drier, or from the drier to the bins, belt conveyors have an advantage over screw conveyors in that the former clean themselves, thus preventing the mixing of varieties when lots of different kinds are being handled. It was observed at one place that the bins were constructed in pairs and in line, so that only one belt conveyor was necessary for conveying the rice from any bin to the elevator.

In the installation of a drier and in the design of the building which houses the drier, provisions should be made for discharging the exhaust air from the drier and preventing its recirculation through the rice. If the air is used in the drier more than once it may become saturated with moisture at a high temperature and retard the evaporation of moisture from the rice. In such cases the rice may actually absorb moisture from the air intended for drying. It is also important that air-intake ports for both the drier and the cooler be well protected from the weather. If this precaution is not taken, rain water may be drawn in with the air; the temperature of the air is thus raised and the water evaporates; this increases the relative humidity and decreases the drying capacity of the air. When moisture-laden air is drawn into the cooler the rice may absorb as much moisture during the cooling process as was evaporated while it was in the drier.

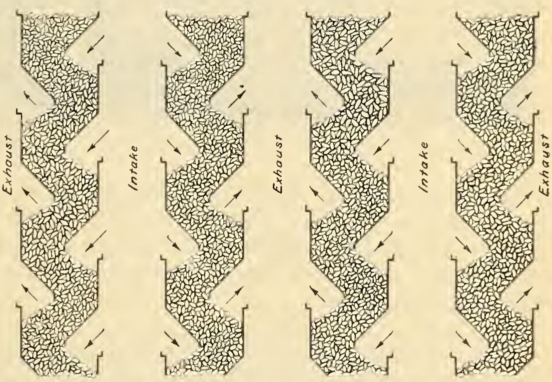

FIGURE 5.—Diagrammatic section of rice columns in drier, DeWitt, Ark.

OPERATION OF THE DRIER

It is advisable to have the drier under the supervision of one person who has no other duties to perform. Driers are designed to operate with little attention but better results are obtained if they are under constant observation. To dry rice artificially so that the dried rice shall be of good milling quality, it is necessary to control the temperature of the drying air, to know the moisture content of the rice before and after each drying operation, and to be able to expose the rice to the drying air for any desired length of time.

Some driers are equipped with a thermostat by means of which the drying-air temperature can be controlled automatically, but if the thermostat fails to function properly, considerable damage may be done to the rice, if prompt attention is not given.

FIGURE 6.—Elevator and drier installation on a farm near DeWitt, Ark.

In sampling the rice for moisture determinations, the samples should be taken so that the results will indicate the average moisture content of the lot. After the moisture content of the rice has been ascertained, a decision should be made as to the number of drying operations required.

FIGURE 7.—Warehouse and drier installation, Nome, Tex.

Most driers have a mechanical device for discharging the grain from the drier at any desired rate. The rate of discharge, in most cases, will depend to a large extent on the moisture content and physical condition of the grain. Rice will usually be discharged at a much greater rate with the same setting of the discharge mechanism after than during the first drying operation. The quality of foreign material as well as differences in shape and size of the kernels of different varieties also affect the rate of discharge on some driers. The operator should check the rate of discharge frequently to be sure that the rice is being exposed for the proper length of time. If the rice is exposed too long it may be injured and if for too short a period an extra drying operation may be required.

A check may be made by noting the time required to fill a container of given volume or by weighing the rice that comes through in a given length of time. The period of exposure can be determined if the capacity of the drying compartment and the number of bushels the drier is discharging per unit of time are known. For example, the drying compartment in the drier under observation at Nome, Tex., held approximately 72 bushels. If it was desired to expose the rice 30 minutes, the discharge was set so that 144 bushels would be discharged per hour, or 2.4 bushels per minute.

It is helpful to the operator to know the rate at which the drier will remove moisture from rice of a given moisture content and

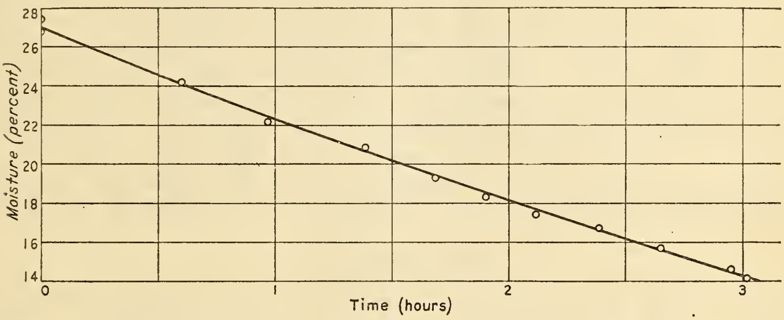

FIGURE 8.—Rate-of-drying curve for commercial drier at Nome, Tex. An average drying air temperature of 123° F. was maintained and the rice was exposed to this air in the drier for approximately 36 minutes each day, the process being repeated until the moisture content of the rice had been reduced to about 14 percent.

with air at a given temperature. A curve was plotted representing the rate of drying at a temperature of approximately 120° F. for the drier at Nome, Tex., and it was found to be very useful in determining the time of exposure necessary for removing a given quantity of moisture. Such a curve is shown in figure 8.

To illustrate the use of this curve, it will be assumed that a lot of rice with a 24 percent moisture content is to be dried to 14 percent moisture. (Tests have shown that the rice will not be injured if the moisture content is reduced as much as 4 percent during the first drying operation, provided the rice contains moisture much in excess of 20 percent.) It is decided to dry the rice four times, with a drying temperature of 120° F., removing 4 percent moisture during the first drying operation and 2 percent during each of three other successive operations. Note the point where the 24 percent moisture-content line intersects the curve and then the point where the 20 percent line does so. It will be seen that an exposure of approximately 50 minutes would be required for the drier to reduce the moisture of the rice from 24 to 20 percent. For the next three drying operations an exposure of about 30 minutes each would be required.

Commercial rice driers will usually do the work for which they are designed without changes or alterations on the part of the operator. In some cases, however, it has been found necessary to make certain changes. To dry rice satisfactorily the drying air must be forced through the rice or otherwise brought in contact with each kernel. Because of the design of certain types of driers or because of the temperature and pressure of the drying air used, the air sometimes passes from an intake to an exhaust port without passing completely through the column of rice. When this occurs it is necessary to close such ports on the intake and exhaust sides of the drier as to cause the air to pass directly through the columns of rice in the drier.

The rice grains will "funnel" in some types of driers when rice is being dried in a continuous flow through the drier. When this occurs the rice near the center of the drier is exposed to the drying air for only a few minutes whereas that near the sides of the drier may be exposed for several hours. In the case of one drier in which funneling was reported, it was found that angle-iron supports for the cut-off valves between the drier and cooler, and between the cooler and the discharge hopper, were placed near the outer edges of the drier. These supports were shifted to a position near the center of the drier and placed about 6 inches apart, which changes practically eliminated funneling. The opening in the bottom of the discharge hopper extended across the center of the drier and at right angles to the columns or ribbons of rice in the drier. This had a tendency to make the rice funnel which was augmented by the obstruction in the form of valve supports near the sides of the drier.

ELEMENTS OF COST

The power, labor, and fuel requirements in the operation of a commercial drier depend to some extent on the type and size of the drier used, skill of the operator, weather conditions, and the quantity of rice dried in continuous operation. As a general rule the cost of operating a large drier is less per bushel of rice dried than for a small drier of the same make, because labor requirements are about the same regardless of the size of unit, and less power is required per unit quantity of rice dried. The operator of practically any drier, however, can reduce the cost of drying by timely firing and by so arranging the drying operations as to keep the drier in continuous operation over long periods. As much fuel may be required to get up steam or to heat a furnace as is required to dry a small lot of rice.

Table 3 shows the approximate operating cost (power, labor, and fuel) for individual drying operations for several lots and varieties of rice, based on tests made during the 1930 harvest season at DeWitt, Ark., and during the 1931 harvest season at Nome, Tex. The cost of man labor, fuel, and electric current is based on prevailing prices on the farms referred to for the 1930 and 1931 harvest seasons. The actual power, labor, and fuel requirements in drying a given quantity of rice would probably vary only slightly at these plants from year to year, but the unit cost of such services has changed somewhat since 1931.

TABLE 3.—*Power and fuel consumed and the approximate operating cost for some lots of rice dried with commercial driers at DeWitt, Ark. in 1930 and at Nome, Tex. in 1931*

Variety	Rice: Quantity[2]	Rice: Drying operations	Rice: Reduction in moisture	Rice: Time exposed	Rice: Estimated yield of headrice per barrel: Before	Rice: Estimated yield of headrice per barrel: After	Air: Atmosphere: Temperature	Air: Atmosphere: Relative humidity	Air: Entering rice	Power[1]: Kilowatt-hours	Power[1]: Cost	Labor: Time	Labor: Cost	Fuel: Quantity[3]	Fuel: Cost	Operating cost: Total	Operating cost: Per bushel
DEWITT, ARK., 1930																	
	Bushels	*Number*	*Percent*	*Hours and minutes*	*Pounds*	*Pounds*	*°F.*	*Percent*	*°F.*	*Number*	*Dollars*	*Hours and minutes*	*Dollars*		*Dollars*	*Dollars*	*Dollar*
Early Prolific	4,472	First	16.8—14.0	1 10	74	79	80.1	50.5	110.5	257	7.71	26 15	13.13	836	4.24	25.08	0.0056
Do	4,468	First	17.0—14.4	1 07	82	89	81.8	69.0	110.5	341	10.23	35 07	17.56	829	4.20	31.99	.0072
Japan	}	First	19.4—16.7	1 09	69	81	72.1	55.7	111.5	147	4.41	15 15	7.62	310	1.57	13.60	
	}	Second	16.7—14.5	1 10	81	94	66.9	87.2	112.7	136	4.08	15 25	7.71	572	2.90	14.69	
	} 2,650	Third	14.5—13.7	58	94	97	80.3	59.2	96.5	123	3.69	12 45	6.38	328	1.66	11.73	
Total		3	5.7	3 17						406	12.18	43 25	21.71	1,210	6.13	40.02	.0151
Japan	2,243	First	17.3—13.9	1 14	84	95	62.1	39.0	109.9	159	4.77	13 50	6.91	781	3.96	15.64	.0070
NOME, TEX., 1931																	
Early Prolific	}	First	20.1—15.8	1 15	73	82	84.0	56.2	120.3	112	3.36	10 30	5.25	60	1.80	10.41	
	} 604	Second	15.8—14.8	36	82	80	92.8	47.5	121.0	75	2.25	5 00	2.50	27	.81	5.56	
Total		2	5.3	1 51						187	5.61	15 30	7.75	87	2.61	15.97	0.0264
Early Prolific	}	First	20.3—18.2	19	66	78	89.2	50.4	115.2	62	1.86	3 25	1.71	15	.45	4.02	
	}	Second	18.2—15.7	52	78	79	83.1	72.7	109.5	96	2.88	9 15	4.62	48	1.44	8.94	
	} 765	Third	15.7—14.4	39	79	80	90.7	62.7	110.1	61	1.83	6 55	3.46	27	.81	6.10	
Total		3	5.9	1 50						219	6.57	19 35	9.79	90	2.70	19.06	.0249

[1] Does not include cleaning oı elevating rice at DeWitt, Ark.
[2] Quantity represents the number of pounds of rough rice reduced to the lowest moisture content shown.
[3] Pounds of coke DeWitt, Ark., gallons of oil Nome, Tex.

TABLE 3.—*Power and fuel consumed and the approximate operating cost for some lots of rice dried with commercial driers at DeWitt, Ark. in 1930 and at Nome, Tex. in 1931*—Continued

NOME, TEX.—1931 continued

Variety	Rice						Air				Power		Labor		Fuel		Operating cost	
	Quantity	Drying operations	Reduction in moisture	Time exposed	Estimated yield of headrice per barrel		Atmosphere		Entering rice	Kilowatt-hours	Cost	Time	Cost	Quantity	Cost	Total	Per bushel
					Before	After	Temperature	Relative humidity									
	Bushels	*Number*	*Percent*	*Hours and minutes*	*Pounds*	*Pounds*	*°F.*	*Percent*	*°F.*	*Number*	*Dollars*	*Hours and minutes*	*Dollars*		*Dollars*	*Dollars*	*Dollar*
Fortuna		First	19.7—17.9	27	67	70	88.7	64.5	121.6	82	2.46	5 00	2.50	32	.96	5.92	
		Second	17.9—15.0	32	70	66	92.3	61.6	121.3	53	1.59	5 55	2.96	24	.72	5.27	
	798	Third	15.0—14.2	12	66	69	88.0	63.5	119.2	18	.54	2 15	1.12	11	.33	1.99	
Total		3	5.5	1 11						153	4.59	13 10	6.58	67	2.01	13.18	.0165
Early Prolific	2,400	First	15.4—14.1	18			82.2	45.5	117.7	266	7.98	10 00	5.00	41	1.23	14.21	.0059
Blue Rose		First	25.1—21.4	40	56	64	83.6	53.3	119.9	113	3.39	7 10	3.58	26	.78	7.75	
		Second	21.4—19.2	32	64	81	79.5	72.7	121.6	55	1.65	5 45	2.88	30	.90	5.43	
		Third	19.2—16.7	40	81	95	78.6	80.4	115.6	58	1.74	7 10	3.58	18	.54	5.86	
	783	Fourth	16.7—13.9	39	95	98	76.4	82.4	119.7	60	1.80	7 05	3.54	17	.51	5.85	
Total		4	11.2	2 31						286	8.58	27 10	13.58	91	2.73	24.89	.0318
Blue Rose		First	27.4—24.2	36	49	67	81.4	71.4	133.0	108	3.24	8 05	4.04	40	1.20	8.48	
		Second	24.2—20.9	47	67	74	84.9	64.3	122.0	96	2.88	10 45	5.38	54	1.62	9.88	
		Third	20.9—18.3	36	74	84	79.1	80.6	120.9	78	2.34	8 15	4.12	30	.90	7.36	
		Fourth	18.3—16.7	24	84	86	81.6	70.9	124.2	46	1.38	5 30	2.75	35	1.05	5.18	
	980	Fifth	16.7—14.6	34	86	100	76.1	83.4	121.4	68	2.04	7 45	3.88	36	1.08	7.00	
Total		5	12.8	2 57						396	11.88	40 20	20.17	195	5.85	37.90	.0387
Blue Rose		First	26.8—22.1	58	45	76	81.9	74.6	123.1	154	4.62	15 10	7.58	68	2.04	14.24	
		Second	22.1—19.3	43	76	88	77.5	77.8	121.5	90	2.70	11 15	5.62	51	1.53	9.85	
		Third	19.3—17.4	26	88	83	85.9	68.6	121.5	57	1.71	6 50	3.42	27	.81	5.94	
		Fourth	17.4—15.7	32	83	95	87.9	62.6	122.0	74	2.22	8 25	4.21	34	1.02	7.45	
	1,139	Fifth	15.7—14.1	22	95	101	87.2	60.4	120.4	47	1.41	5 50	2.92	28	.84	5.17	
Total		5	12.7	3 01						422	12.66	47 30	23.75	208	6.24	42.65	.0374

Table 3 includes only those lots of rice on which data were obtained for all drying operations. The average operating cost for individual drying operations was approximately 0.6 cent per bushel for the drier at DeWitt and approximately 0.8 cent per bushel for the drier at Nome. Since four drying operations are usually required in drying rice harvested with a combined harvester-thresher, the total operating cost might be expected to range between 2 and 4 cents per bushel exclusive of fixed charges. The difference in the operating cost of the two plants was doubtless due in large measure to the difference in size of the driers. When operated under similar conditions, with rice of the same moisture content, the drier at DeWitt would probably dry nearly three times as much rice in a 10-hour day as the one at Nome. Moreover, the power requirements shown for the one at DeWitt do not include that required in cleaning and elevating the rice.

Tests made with the drier at DeWitt during the 1929 season show an average cost for individual drying operations of approximately 0.45 cent per bushel exclusive of fixed charges. During that season, however, a much larger quantity of rice was dried than in 1930 and the moisture content of the rice was higher when it was brought to the drier. As a general rule rice with a high moisture content dries at a more rapid rate than does rice with a low moisture content. For this reason the average cost per drying operation is less when the initial moisture content of the rice is high; but the total cost is more than when the initial moisture content of the rice is low.

The overhead expense, which involves interest on the investment and depreciation, is a fixed annual cost, but when computed on a per-bushel basis these fixed charges decrease as the total volume of rice dried per season increases. Thus it is to the advantage of the owner to dry a large quantity of rice each season in order to reduce the overhead cost per bushel.

It is difficult to arrive at any definite value for interest on the investment and depreciation of a rice drier. For instance, in one case where observations were made the drier was installed adjacent to a farm elevator in a locality in which the rice is handled in bulk, whereas another was located in a warehouse in a section where rice is handled in sacks. In the second instance it was necessary to construct bins for storing the rice between drying operations, and the elevating and conveying machinery was an added expense as it was of no use except in connection with the drier.

In localities where rice is handled in bulk, storage bins are a part of the regular equipment. Where rice is handled in sacks, bulk-storage structures must be provided and the expense charged to the drier. The drier at DeWitt represented an investment of approximately $4,550. Of this amount about $3,950 represented the cost of the machinery and equipment installed and $600 the cost of the building in which the drier was housed. The drier at Nome cost approximately $2,000 installed, and the building, including storage bins, about $9,000. Calculating 6 percent interest on the average investment, 10 percent depreciation on the machinery, and 5 percent depreciation on the buildings, the annual fixed cost would be about $561.50 for the drier at DeWitt and $980 for the one at Nome.

The length of life of a drier and auxiliary equipment depends to some extent on the quantity of rice handled each season, but it is doubtful whether variations in the annual usage of such equipment under ordinary conditions would greatly influence the annual fixed cost. The fixed cost per bushel, however, varies inversely with the number of bushels dried per season. If the driers at DeWitt and Nome each handled 10,000 bushels of rice per season, the fixed cost would have been approximately 5.6 and 9.8 cents per bushel, respectively, and the total cost of drying would have been approximately 8 and 13 cents per bushel, respectively. If 20,000 bushels were handled per season, the annual fixed cost would be 2.8 and 4.9 cents per bushel, respectively, for the two plants.

EXPERIMENTAL DRIERS

The structure of the rice kernel is such that it may crack or rupture because of changes in temperature and moisture content. As a general rule, in the case of drying any product, the temperature of the drying air is maintained as high as possible without injury to the product, in order to save expense for power, labor, and fuel.

To determine the maximum drying-air temperature which could be used without injury to the milling quality of the rice, tests were conducted during the 1930 harvest season on an experimental drier set up on a farm near DeWitt, Ark. This unit was furnished by a grain-drier manufacturer and was of the same general design as a commercial drier located on the farm where the tests were conducted.

The experimental drier was of the direct-heat type; coke was used for heating the drying air. The gases were drawn from the furnace, mixed with outside air in a mixing chamber to produce the desired temperature, and forced through the rice by a fan. The temperature of the drying air was controlled by a thermostat which, by means of air pressure, actuated a series of dampers regulating the quantity of hot and cold air admitted. The rice passed down through the drier by gravity and the rate of discharge was controlled by a swinging damper. The drier was divided into two sections or compartments. Hot air was supplied to the upper compartment for drying, and ordinary air was used in the lower compartment for cooling the rice.

In 1931 a small laboratory drier was constructed at Nome, Tex. This experimental drier was made up of a sheet-metal box about 18 by 20 inches in section by 30 inches in height and open at the top. A screen bottom tray, about 8 inches in depth, was made to fit in the top of this box. The bottom of the tray was divided into four equal areas and a sheet metal cylinder, 4½ inches in diameter and 8 inches in height, was supported in a vertical position in the center of each area. The screen wire was cut out beneath each cylinder and the edge of the wire was soldered to flanges at the bottom of the cylinder. Four removable cylinders were made with screen-wire bottoms and of suitable diameter to fit within the other four cylinders which were in a fixed position.

The rice to be tested was placed in the removable cylinders and the screen-bottom tray filled with rice to any desired depth to assist in regulating the quantity of air forced through the test rice. At the beginning of each test a quart sample of rice was placed in each cylinder, filling it to a depth of about 4½ inches. A moisture test was made on a smaller sample taken from the same lot of rice. The quart sample of test rice was weighed before being placed in the cylinder and at regular intervals during the drying process. By knowing the moisture content and weight of the rice in the cylinders at the beginning of the test, it was possible to compute the weight of the rice when the moisture content had been reduced to 14 percent.

The air used for drying was heated by an electric heater and was forced into the bottom of the box and up through the rice by a fan. An anemometer was used in measuring the velocity of the air in each cylinder after it had passed through the rice.

In all of the tests made with the experimental drier the effect of drying on the rice kernel was checked against results obtained by allowing rice from the same lot to dry naturally. A portion of each sample had been placed in a wire basket in the laboratory where it was allowed to remain until the moisture content had reached approximately 14 percent. No heated air was applied to these portions of samples and no effort was made to force the evaporation of moisture except that a fan was used to agitate the air slightly surrounding the baskets.

To ascertain by a definite test the effect of different methods of drying on the milling quality of the rice, each sample was tested for hardness with a Smith shelling device. This is the official device used in testing samples for milling quality in applying the United States standards (grades) for rough rice. The official conversion table was used to convert the figures for shelling-device results into terms of estimated yields of head rice per barrel.

TEMPERATURE OF DRYING AIR

In 1930 tests were made with the experimental drier at DeWitt to determine the effect of the drying-air temperature on the milling quality of rice. Most of these tests were made with the rice in continuous flow through the drier but some batch-drying tests were made. Average results of all tests are shown in figure 9. The rice dried with heated air showed a lower milling quality than samples of the same lot of rice dried under ordinary air conditions. The reduction in yield of head rice per barrel of rough rice was, however, greatly accelerated by the use of a drying-air temperature in excess of approximately 120° F.

In 1931 a series of tests was conducted at Nome, in which samples of individual lots of rice were dried to approximately 14 percent moisture in one operation with the drying air at a temperature of 110°, 120°, 130°, and 140° F., and similar samples of the same lot were dried at the same respective temperatures but exposed to the drying air only 1 hour each day until dry.

Average results of such tests made with Early Prolific, Fortuna, and Blue Rose rice are shown in figure 10.

Under the test conditions 120° F. seemed to be the maximum drying-air temperature that would not cause appreciable injury to the rice when dried 1 hour each day. In practically all cases a lower yield of head rice was indicated when samples of a given lot were dried with heated air at any temperature than when samples were allowed to dry naturally at ordinary air temperatures, but the yield decreased more rapidly with temperatures in excess of, than with temperatures lower than, 120°.

The data also indicate that some varieties of rice are subject to greater injury from high temperatures than others. The indications

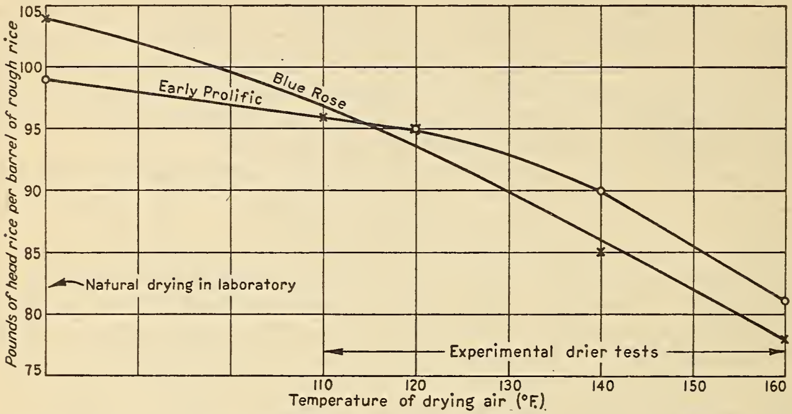

FIGURE 9.—Effect of the drying-air temperature on the estimated yield of head rice in pounds per barrel of rough rice when dried to a moisture content of approximately 14 percent.

from these tests are that Early Prolific rice will stand a higher drying-air temperature than either Blue Rose or Fortuna. Samples of Fortuna rice dried at one continuous operation at a temperature

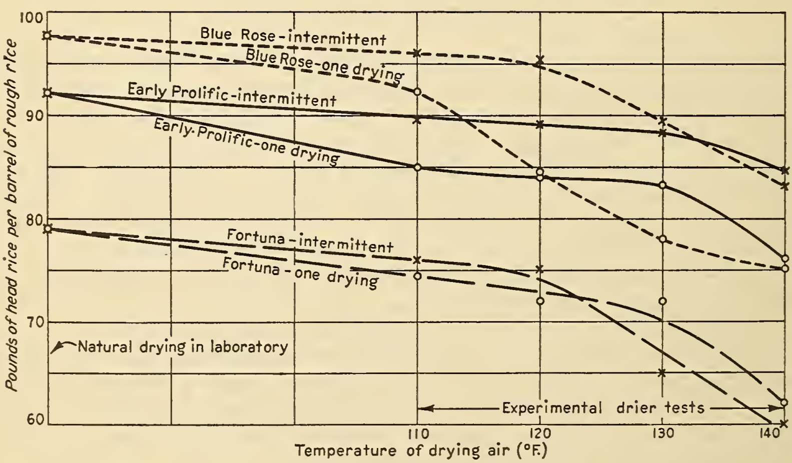

FIGURE 10.—Effect of drying-air temperature and method of drying on the estimated yield in pounds of head rice per barrel of rough rice when dried to a moisture content of approximately 14 percent.

of 130° or 140° F. showed a higher milling quality than samples of the same rice dried with an exposure of 1 hour each day at corresponding temperatures. It may be that not a sufficient number of tests were made with Fortuna rice to give reliable averages.

AIR VELOCITY AND RATE OF DRYING

Observations and tests made with both commercial and experimental driers prior to 1931 showed that rice may be seriously damaged when high drying temperatures are used. It was not known, however, whether the injury was caused by the temperature of the drying air, the rate of drying, or the total quantity of moisture removed at one drying operation. To obtain some information on these points, samples of the same lot of Fortuna rice were dried at different air velocities, but at the same temperature and with the same period of exposure each day. The rice that was dried with a velocity of approximately 88 feet per minute, or 88 cubic feet per minute per square foot of area, with an exposure of 1 hour each day until dry, showed a lower yield than that dried at a velocity of 45 feet per minute. A further reduction in yield was obtained with an air velocity of about 130 feet per minute with the same temperatures and period of exposure.

These results seem to indicate that the rate of drying and the total quantity of moisture removed at one drying operation are chiefly responsible for injury to the milling quality of the rice. This opinion was also borne out in additional tests with Blue Rose rice, on which a series of tests were made including variations in air velocity, temperatures, and period of exposure for different samples of the same lot. With one exception, a lowering of milling quality resulted with an increase in air velocity, an increase in temperature, or an increase in the period of exposure for each drying operation. An increase in temperature, or an increase in air velocity, accelerated the rate of evaporation of moisture, and this has a tendency to crack or rupture the rice kernels. With either a high temperature or a high air velocity, but with a short period of exposure, only a small quantity of moisture was removed from the rice during each operation—probably the greater part of which was from the hulls and the outer surface of the kernels—and little damage was done to the milling quality of the rice. The effect of temperature on the rate of drying is indicated in figure 11. If either a high temperature or a high air velocity is used, the time of exposure for each drying operation should be reduced in order to obtain rice with the maximum yield in pounds of head rice per barrel of rough rice.

It was also found that the time of exposure for each drying operation had a considerable influence on the rate of drying. When rice is left in storage between drying operations the moisture tends to become evenly distributed in the kernels. When it is again subjected to the drying process the moisture in the hulls and in the outer coating of bran is given off quickly, but as diffusion of moisture from within to the surface of the kernels begins, the rate of evaporation is retarded. This is illustrated in figure 12 which shows that as the period of exposure for each drying operation is decreased the total time required to dry the rice is also decreased. Approximately 4 hours were required to reduce the moisture of rice from about 26 to 14 percent at a temperature of 120° F. when dried in one operation. When samples of the same rice were dried with air under practically the same conditions, but were exposed for an hour each day until dry, the total time required was approximately 3 hours. With an exposure of 30 minutes each day, only 2 hours and 20 minutes were required to dry the rice.

The retarding effect of diffusion of moisture to the surface of the kernels on the rate of evaporation is illustrated in figure 12 by the

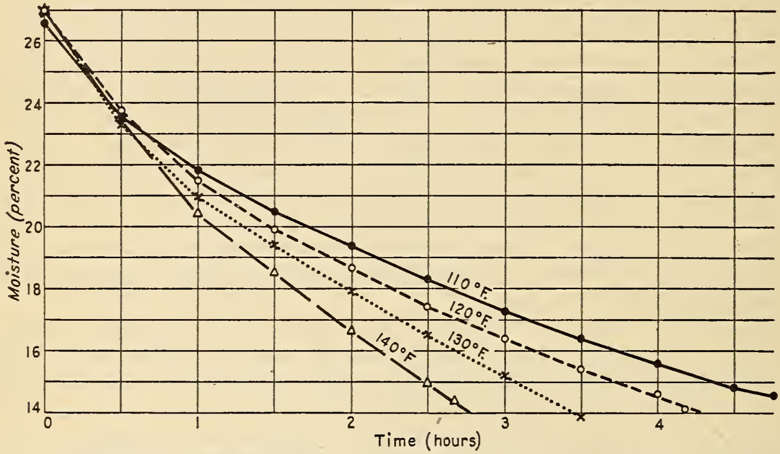

FIGURE 11.—Effect of the temperature of the drying air at a velocity of approximately 47 feet per minute on the rate of drying Blue Rose rice when dried at one operation.

curve showing the rate of drying when the rice was exposed for 1 hour each day. For the first 30 minutes during the first drying operation, the moisture content of the rice was reduced approximately 3.4 percent; during the remaining 30 minutes of the period

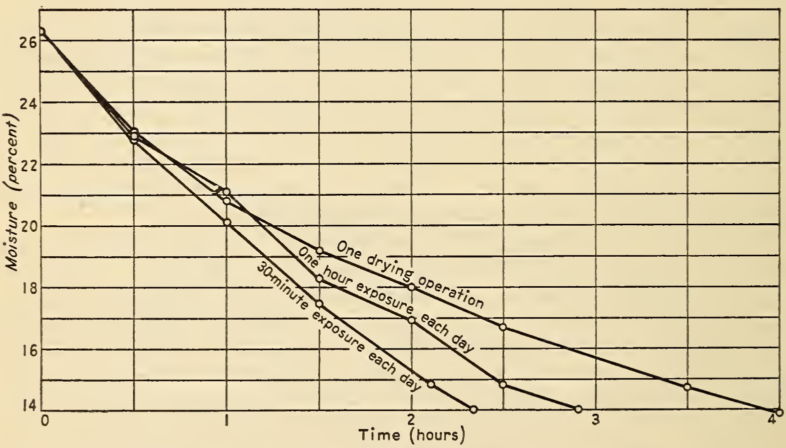

FIGURE 12.—Effect of time of exposure for each drying operation on the rate of drying Blue Rose rice with air at a velocity of approximately 48 feet per minute and a temperature of approximately 120° F.

the reduction in moisture was only 1.8 percent. For the first 30 minutes of the second drying operation the reduction was 2.8 percent and for the second half of the operation only 1.4 percent. For the first 30 minutes of the third drying operation there was a reduction in moisture of 2.1 percent and for the remaining 25 minutes of the test only 0.8 percent.

Figure 13 shows the effect of air velocity or quantity of air supplied per minute per unit quantity of rice, on the rate of drying with the air at a temperature of about 120° F. and with an exposure of 30 minutes each day. Results of these tests show that as the air velocity is increased the rate of drying is also increased, but not in proportion to the increase in velocity. This is because rice of a given moisture content will lose moisture at a given rate provided the air conditions are constant; but air velocity in excess of that necessary to remove the moisture as it is lost by the rice kernel is of no additional value.

The air velocity, or quantity of air supplied per minute per bushel of rice in a commercial drier, may vary depending in part upon the make and model of drier used. In practically all commercial rice

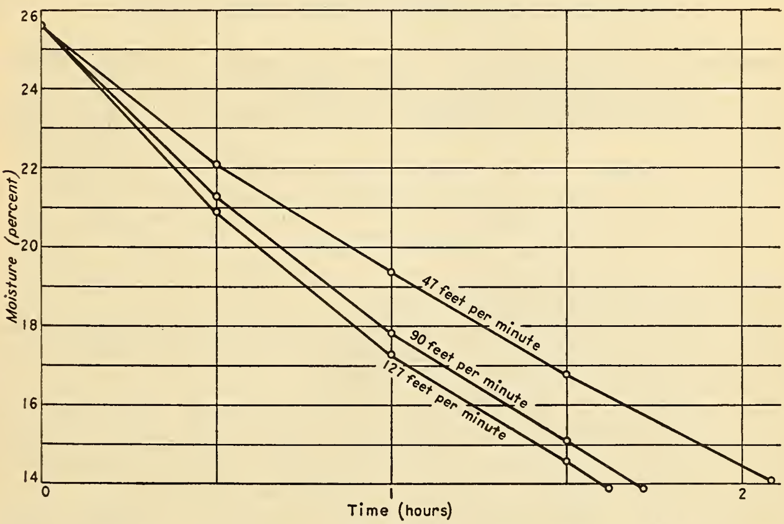

FIGURE 13.—Effect of air velocity at a temperature of approximately 120° F. on the rate of drying Blue Rose rice with an exposure of 30 minutes daily.

driers the drying air is forced through thin layers or columns of rice, for two reasons—to facilitate uniform drying and to permit the circulation of a large volume of air through a given quantity of rice without excessive power requirements.

With a given fan and within certain limits, the power required varies with the cube of the quantity of air supplied when the fan is operating against a given resistance. For this reason it would not be advisable materially to increase the quantity of air supplied by a given fan on a commercial drier without changing the design of the drier. Even though a larger motor or engine might be installed to supply the additional power required, the cost of power might offset any gain in rate of drying due to an increase in the quantity of air supplied. According to tests made with both experimental and commercial driers, air is usually supplied at the rate of from 100 to 150 cubic feet per minute per bushel of rice in the drier.

EFFECT ON GERMINATION

Germination tests were made on samples of Blue Rose rice dried in the laboratory under normal air conditions and in the experimental drier at DeWitt with air at 110°, 120°, 130°, and 140° F. Results of similar tests made on samples of Early Prolific, Fortuna, and Blue Rose rice dried in the experimental drier at Nome, gave no indication of injury resulting from artificial drying at the temperatures used. Additional tests made in a greenhouse on some of the samples of rice gave no clear evidence of any difference in the seedlings from the samples dried at different temperatures. Samples were obtained from a lot of seed rice dried with a commercial drier with air at a temperature of approximately 120° and no indication was found of injury to germination resulting from the drying operation.

PRACTICAL CONCLUSIONS FOR THE TRADE

Artificially dried rice should remain in storage for a few days before it is milled or sampled for official grading.

Rice harvested with a combine should usually be cleaned before drying.

If it is necessary to dry a given lot of rice in one operation, a drying-air temperature in excess of 110° F. should not be used.

A drying-air temperature of 120° F. can be used without injury to the rice if the moisture content is reduced only about 2 percent at each drying operation and the rice is allowed to remain in storage from 12 to 24 hours between dryings.

Small lots of rice should be consolidated whenever possible as bin space, fuel, and labor can be conserved in drying large lots and in keeping the drier in continuous operation.

Commercial driers will usually do the work for which they are designed without changes or alterations on the part of the operator. Under ordinary conditions no attempt should be made to increase the quantity of air supplied by a fan as the increase in the power requirements may offset any gain in rate of drying. In some driers, however, the rice may funnel, causing uneven drying. This trouble can usually be rectified on some driers by changing the position of supporting members for the shut-off valves between the drier and cooler and between the cooler and discharge hopper.

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